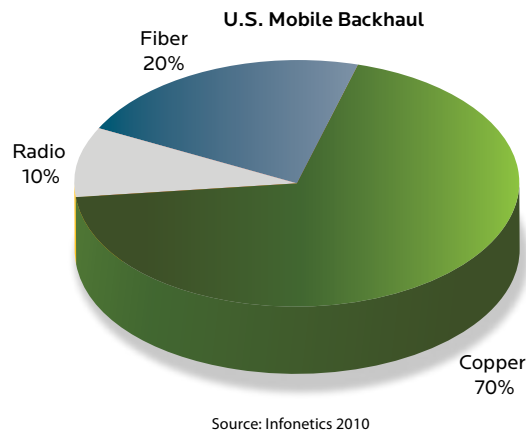


ATTACHMENT 2

CARRIER ETHERNET BACKHAUL STRATEGIES

A quick scan of industry headlines emphasizes the importance of a Carrier Ethernet solution for mobile backhaul. Most towers need new broadband fiber or Ethernet radio backhaul to address the 10's to 100's of Megabits of capacity at the cell tower for 3G and 4G services. The solution must be optimized to support the rapid growth of Ethernet for 3G and 4G services, while continuing to support DS1 for 2G voice services which remain at the tower for up to 10 years.

The performance requirements are rigorous; this is a carrier infrastructure application that must deliver DS1 that meet the performance requirements of ITU G.823/G.824, ITU G.8261, and the Ethernet must have fine-grain service management and Operations, Administration and Maintenance (OAM) support. The solution must enable CAPEX efficiencies significantly better than SONET, without compromising on the 50ms protection switching and 99.999% availability required by carriers.



Mobile backhaul and enterprise access networks must be architected with Carrier Ethernet solutions to deliver 99.999% availability, 50ms protection switching, flow-level SLA management, end-end OAM, performance and resiliency.

These networks must also cost significantly less than SONET/SDH, enable massive Ethernet scaling and continue to support high-performance DS1 for 2G mobile and private line applications.

— Scott Knox, Director
Solutions Development

MULTI-APPLICATION, MULTI-CUSTOMER

Ethernet for 3G and 4G services gets the majority of the attention in the headlines, and rightfully so. The explosion of bandwidth growth for these services is the driver for the significant infrastructure investment required to support demands that scale from 20Mb to 100's of Mb at each tower. The 3G and 4G radio at the tower is either IP or Ethernet based; a Carrier Ethernet infrastructure is optimal to support these applications.

It is important to note that the addition of 3G or 4G services to a tower does not mean that the existing services or applications go away. Instead, these are overlays, with the existing infrastructure continuing to exist and in most cases continue to expand for the foreseeable future. This means that a wireless carrier needs DS1 for 2G voice applications in addition to Ethernet services for 3G and 4G applications.

The majority of cell sites in North America are now multi-tenant, with more than one wireless carrier on the tower. In 2000, there were 104,000 cell sites, with an average of 1.5 carriers per tower; in 2009 there were 266,000 cell sites with an average of 2.6 carriers per tower. This trend will continue, as it is more cost effective to co-locate on an existing tower with another carrier as each carrier continues to expand their 3G/4G footprint.

This means that the backhaul solution to serve the tower should be optimized to service multiple customers on shared infrastructure as shown in Figure 1 instead of having dedicated backhaul for each wireless carrier.

Year	Cell Sites	Carriers Per Tower
2000	104,288	1.5
2009	266,623	2.6

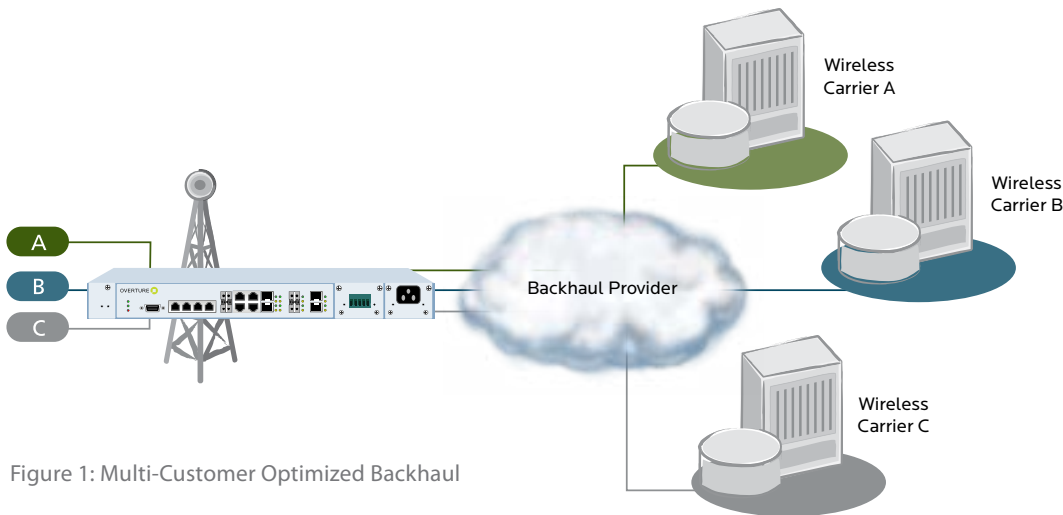


Figure 1: Multi-Customer Optimized Backhaul

ETHERNET PERFORMANCE REQUIREMENTS

Ethernet service requirements have evolved from port-based best effort transport to high performance flow level managed services with differentiated classes of service and robust SLAs. To meet these new service requirements, carriers need standards-based visibility, manageability, scalability and controls enabled by Ethernet Service OAM.

In the competitive services marketplace, customers are now requiring SLAs backed by standards-based Ethernet OAM as table-stakes to win their business. It is no longer enough to only offer coverage or a competitive price, carriers must now differentiate by offering a combination of coverage, price and performance.

Market leading backhaul service providers are responding to those changing requirements by offering flexible bandwidth services, multi-point connectivity, multiple EVCs and robust CoS profiling, policing and shaping. Combining many flows with differing CoS enables higher-value services. Delivering these services in a large-scale multi-point WAN environment enables greater CAPEX, OPEX and scalability advantages. Without the ability to monitor and manage at the flow level, either the network cannot scale or differentiated services cannot be supported. To scale these advanced services, Ethernet OAM visibility of the connectivity and performance at the flow level is paramount.

QUICK REVIEW OF ETHERNET OAM

Ask an Ethernet technologist about Ethernet OAM and you'll usually get the response, 'ah-ag-1731'. For the uninitiated, this is the short-hand answer for the ITU and IEEE Ethernet OAM standards that are the table stakes for carrier class Ethernet services.

IEEE 802.3ah – 802.3ah provides link level Connectivity Fault Management (CFM) for port level connectivity management to the next-hop device. 802.3ah provides discovery, remote failure indication, loopback, dying gasp and critical event capabilities. Standardized in 2004, 802.3ah is a capability in most devices.

IEEE 802.1ag – 802.1ag takes the concept of CFM to a network context; enabling discovery, monitoring and management of every device end-end, including intermediate devices. Capabilities include discovery, continuity check, loopbacks, link trace, remote failure monitoring and Alarm Indication Signal (AIS). These capabilities can be enabled for multiple domains, including the network operator, service provider and customer. These CFM tools can be applied to the EVC level, providing flow level monitoring and management and are non-intrusive to customer flows.

ITU Y.1731 – Y.1731 has both a CFM and a performance management (PM) component. The CFM capabilities of Y.1731 are functionally very similar to IEEE 802.1ag. The PM capabilities of Y.1731 include frame loss, frame delay, frame delay variation and throughput measurement. Similar to 802.1ag, these capabilities can be enabled end-end, for multiple domains, and are non-intrusive to customer flows.

The Ethernet services that are required are much more than a fat-pipe of best-effort traffic. To provide the performance, scalability, and CAPEX efficiencies required, the solution must be architected to support multiple carriers and multiple applications with flow-level service creation and service assurance. Wireless carriers demand flow-level SLA controls, including profiling, policing and shaping. It must be class-of-service aware and provide robust QoS controls.

Service assurance at the flow level with Carrier Ethernet OAM powered by .ah, .ag, and Y.1731 is table stakes for this application. Continuous real-time SLA management for both Fault and Performance must be provided with these standards-based management tools.

Carriers should look for solutions that are certified to meet the gold-standard for circuit emulation over Ethernet – MEF18.



DS1 PERFORMANCE REQUIREMENTS

Equally important is the performance requirements for the DS1 services, as 78% of the total revenue still comes from voice services. These DS1s must continue to meet ITU standards G.823, G.824 and G.8261 – the same as SONET/SDH with no compromises. To do this requires a solution that is architected to deliver in a real-world network as defined by MEF18 and ITUG.8261. The real-world backhaul can have up to 10 switches in series, with fluctuating loading, congestion and failure scenarios. Carriers should look for solutions that are certified to meet the gold-standard for circuit emulation over Ethernet – MEF18.

Timing is a critical part of delivering MEF18 certified solutions. Characteristics of a high performance solution include:

- Stratum3 clock
- Separate timing domain for every circuit
- Hardware based for deterministic performance in all loading conditions
- Performance tuned adaptive timing
- Differential timing solutions with either 1588v2 or Synchronous Ethernet.

CAPEX EFFICIENCY

The scope of the modern mobile backhaul application narrows the architectural options to a few choices which can satisfy the technical requirements. The solution must support scalable IP/Ethernet services for 3G/4G and continue to support DS1 for up to 10 years. Three technologies for consideration are:

- SONET: Ethernet-over-SONET for 3G/4G and TDM DS1
- Cell-site Routers - IP/MPLS for 3G/4G and DS1 PWE for 2G
- Carrier Ethernet - Ethernet for 3G/4G and DS1 PWE for 2G

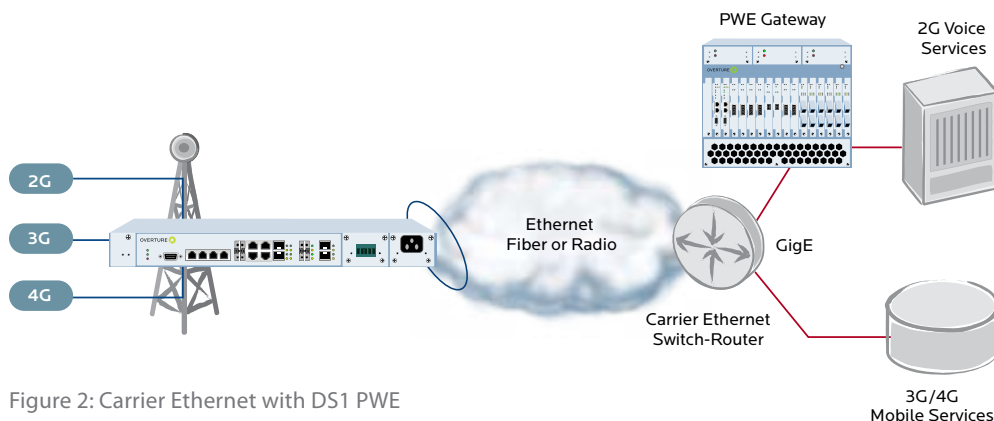


Figure 2: Carrier Ethernet with DS1 PWE

While all 3 technologies can support the service mix and scalability, the CAPEX requirements indicate a clear architectural winner. A Carrier Ethernet solution with circuit emulation is 3 to 4 times more CAPEX efficient than either SONET/SDH or router-based solutions as shown in Figure 3.

CAPEX COMPARISON			
1,000 Towers w/3 carriers	SONET MSPP	Router-based network	Ethernet PWE
Tower	\$12M	\$8.5M	\$4.5M
Hub, Swith, Transport	\$21.9M	\$18.6M	\$4.0M
Total CAPEX	\$33.9M	\$27.1M	\$8.5M
% CAPEX Increase	298%	218%	

Ethernet 3x to 4x more CAPEX efficient

Figure 3: CAPEX Comparison, Ethernet vs. SONET or Router

CAPEX OPTIMIZATION STRATEGIES

There are a number of ways to optimize backhaul CAPEX. Depending on the scale, scope and network planning strategy of a particular carrier, the most significant optimization factors may be different. Areas for consideration include:

FIBER UTILIZATION EFFICIENCY

The single most expensive component in providing backhaul services to the tower is getting fiber or microwave radio to the tower. Backhaul providers who own fiber infrastructure may be 'fiber-rich' in some portions of their network, but will have other areas where their fiber assets are limited or where they must use dark-fiber leases to reach towers. Some backhaul providers may rely heavily on fiber leases or Off-net Ethernet service leases to reach the tower.

Solutions which increase the fiber utilization efficiency should be a fundamental tool in every carrier network design toolbox. One of the most effective ways to increase efficiency is with a G.8032 Ethernet Multi-node Ring. Serving multiple tower locations with a multi-node ring solution instead of dedicating a fiber pair for each tower provides significant fiber efficiency improvement. If for example, 10 towers are combined on a G.8032 Ethernet multi-node ring as shown in Figure 4, only a single fiber pair is consumed instead of 10 fiber pairs. In addition to the order-of-magnitude improvement in utilization, these towers would also now have diverse-route protection with 50ms protection switching.

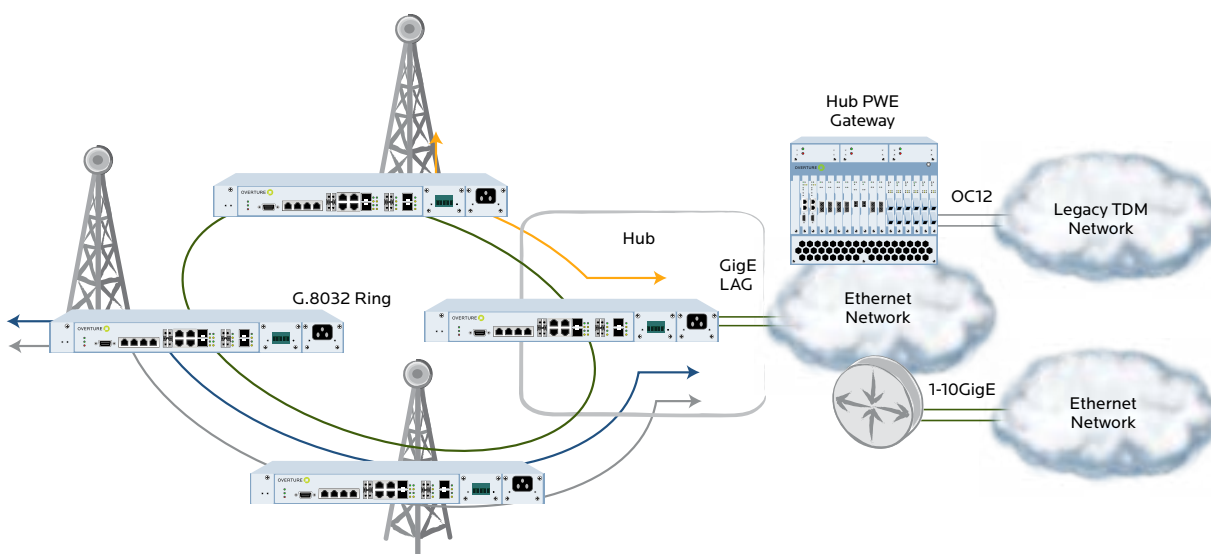


Figure 4: Multiple Towers on a G.8032 Ethernet Ring

CELL SITE CAPEX EFFICIENCY

The best way to optimize CAPEX at the cell site is to use a Carrier Ethernet solution that integrates Ethernet service and OAM management as well as DS1 service management into a single converged platform. Using a Carrier Ethernet solution instead of SONET or Ethernet results in a 3x-4x improvement in CAPEX efficiency.

There are several ways to optimize the cell-site solution, depending on the planning approach of the backhaul provider, and on the number of wireless customers to be served at the tower.

Multi-customer aggregation – Some backhaul providers prefer to deploy a cabinet on the cell-site compound, or adjacent to the site to serve all the customers at the tower as shown in Figure 5. Leveraging the economy of scale of serving 3 or 4 customers on a single platform at the tower saves CAPEX compared to a dedicated service device for every customer.

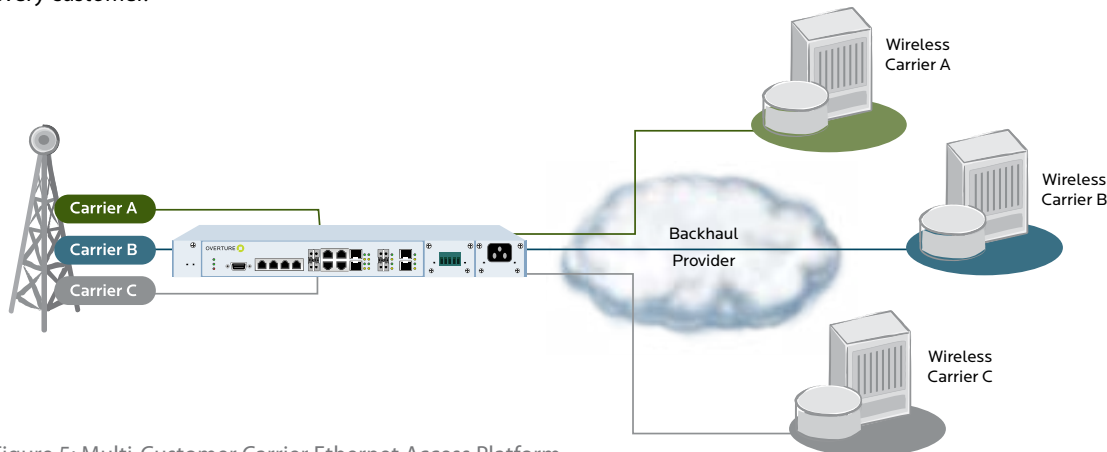


Figure 5: Multi-Customer Carrier Ethernet Access Platform

G.8032 Ring Node per Customer – Some backhaul providers prefer to deploy a dedicated service edge device directly in the wireless carrier cabinet. This saves the cost of deploying and powering a dedicated cabinet, but does not allow supporting other wireless carriers at the tower. A G.8032 ring solution enables optimization for this architecture as shown in Figure 6:

- Dedicated service platform in each wireless carrier cabinet, leveraging customer space and power.
- Dedicated customer nodes are part of a G.8032 infrastructure ring, using a single fiber pair for multiple customers and multiple towers.
- 50ms protection switching for all nodes on the ring.

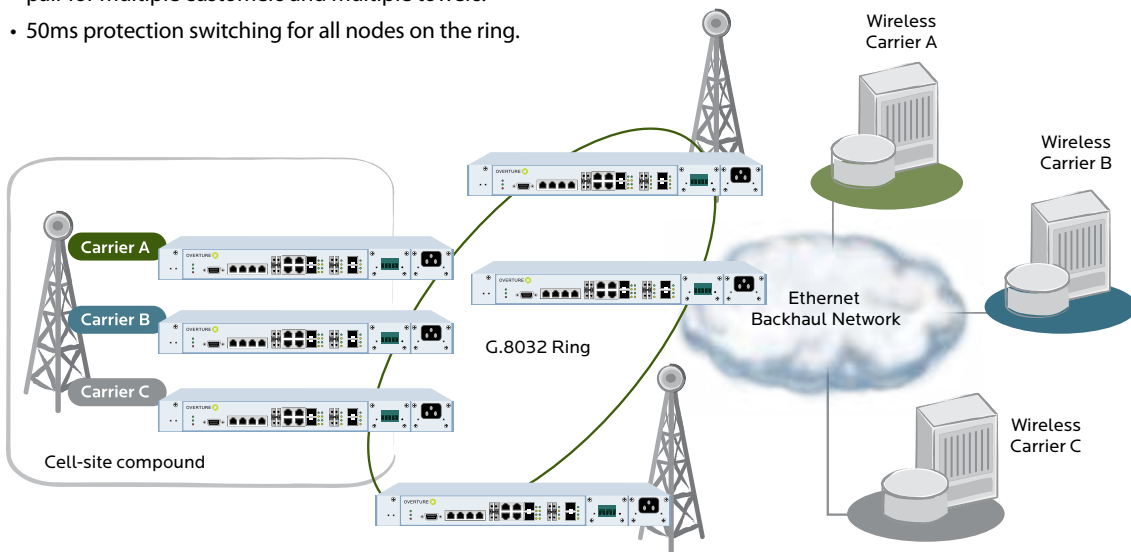


Figure 6: G.8032 Enables Dedicated Customer Device without Sacrificing Fiber Efficiency

HUB CAPEX EFFICIENCY

The choice of technology at the tower pays dividends for hub CAPEX efficiency as well. Aggregation at the tower using G.8032 means multiple towers are supported on an aggregated 1GigE/10GigE protected uplink to the hub aggregation point. This dramatically reduces the number of ports required on the hub aggregation device. For example, 10 towers aggregated on a G.8032 ring, require two ports on the hub aggregation switch compared to 20 ports in a hub-and-spoke architecture. The result is an order-of-magnitude reduction in hub port cost as shown in Figure 7.

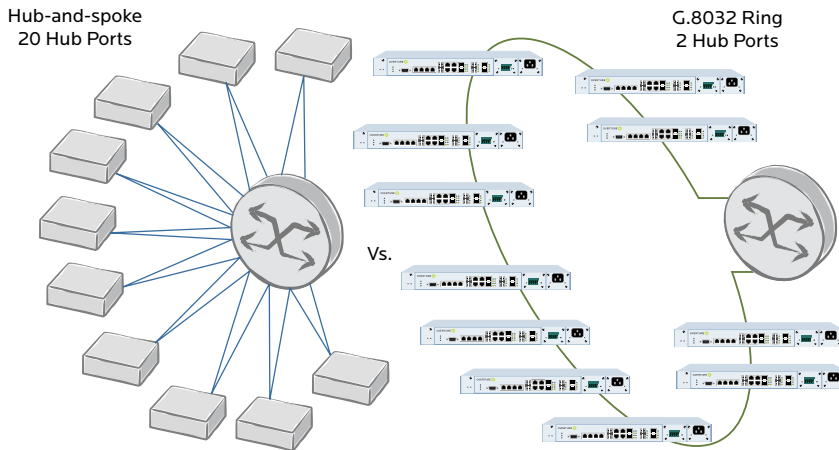


Figure 7: Hub-and-Spoke vs. G.8032 Port Efficiency

Carriers should consider whether to use a Packet-Optical Transport Platform (P-OTP) or a Carrier Ethernet Switch (CES) instead of routers for aggregation, transport and switching. A P-OTP or CES architecture can offer higher performance with connection-oriented solutions for mobile backhaul compared to a routed network. A P-OTP or CES solution is 2.5x-4x more CAPEX efficient than a router-based solution for mobile backhaul.

While some CESR vendors provide DS1 pseudowire blades for their core routers, these blades are low density and expensive. A better solution is to use a purpose-built, scalable hub PWE gateway that is cost optimized to scale to support over 1,000 protected DS1s as shown in Figure 8. Using a Carrier Ethernet hub PWE gateway is 3x to 6x more CAPEX efficient than a router-based solution. This has the added benefit of freeing up high-capacity router slots for more appropriate high density GigE or 10GigE blades for other applications.

SUMMARY

Backhaul providers need to enable solutions that deliver the fine-grain service management and service OAM without having to compromise on the 99.999% availability and 50ms protection switching that they get from today's SONET/SDH solutions. In addition, most networks have a continuing need for DS1 for legacy applications which will remain for up to 10 years.

A Carrier Ethernet solution which supports G.8032 Ethernet multi-node ring as well as TDM Pseudowire over Ethernet meets all of the service and performance requirements for mobile backhaul, enterprise access and infrastructure applications. These Carrier Ethernet solutions not only meet the services and performance needs, they also deliver a 3x to 4x CAPEX efficiency improvement compared to SONET/SDH or Router-based solutions.

ABOUT OVERTURE

Overture is the preferred Carrier Ethernet edge and aggregation partner to more than 450 service providers and enterprise customers worldwide. By providing the entrance to a better network, service providers can leverage Carrier Ethernet to multiply revenue and streamline operational costs by enabling high-capacity Ethernet services over any physical media, including fiber, copper and TDM. Overture's solutions are designed for reliability and ease of use, and arm customers to compete for demanding applications such as cloud computing and mobile communications that require greater bandwidth and smarter networks. Overture is headquartered in Research Triangle Park, NC, with a technology center in Richardson, Texas. For more information, visit www.overturenetworks.com.

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ACRONYMS

CCM	Continuity Check Messages
CES	Carrier Ethernet Switch
CESR	Carrier Ethernet Switch Router
CFM	Connectivity Fault Management
CoS	Class of Service
EVC	Ethernet Virtual Circuit
OAM	Operations, Administration and Management
PM	Performance Management
P-OTP	Packet-Optical Transport Platform
PWE	Pseudowire Encapsulation
QoS	Quality of Service
SLA	Service Level Agreement



Overture Networks, Inc.
Research Triangle Park, NC
tel: 919.387.4100
www.overturenetworks.com